XVII. *On Gouty and Urinary Concretions.* *By* William Hyde Wollaston, *M. D. F. R. S.*

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If in any case a chemical knowledge of the effects of diseases will assist us in the cure of them, in none does it seem more likely to be of service than in the removal of the several concretions that are formed in various parts of the body. Of these one species from the bladder has been thoroughly examined by Scheele, who found it to consist almost entirely of a peculiar concrete acid, which, since his time, has received the name of lithic.

In the following paper I purpose giving an account of the analysis of gouty concretions, and of four new urinary calculi.

The gouty matter, from its appearance, was originally considered as chalk; but from being found in an animal not known to contain or secrete calcareous earth uncombined with phosphoric acid, it has since been supposed to resemble earth of bones. Dr. Cullen has even asserted, that it is 'very entirely' soluble in acids. The assertion, however, is by no means generally true, and I think he must, in all probability, have used the nitrous acid, for I find no other that will dissolve it.

Another opinion, and, I believe, at this time the most prevalent is, that it consists of lithic acid, or matter of the calculus described by Scheele. But this idea is not, I believe, founded

on any direct experiments, nor is it (to my knowledge) more ably supported than by Mr. FORBES, who defends it solely by pathological arguments from the history of the disease. Had he undertaken an examination of the substance itself, he would have found that, instead of a mere concrete acid, the gouty matter is a neutral compound, consisting of lithic acid and mineral alkali; as the following experiments will prove.

(1.) If a small quantity of diluted vitriolic acid be poured upon the chalk-stone, part of the alkali is extracted, and crystals of GLAUBER'S salt may be obtained from the solution. Common salt may still more easily be procured by marine acid. The addition of more acid will extract the whole of the alkali, leaving a large proportion of the chalk-stone undissolved; which exhibits the following characteristic properties of lithic matter.

(*a.*) By distillation it yields a little volatile alkali, Prussic acid, and an acid sublimate, having the same crystalline form as the sublimate observed by SCHEELE.

(*b.*) Dissolved in a small quantity of diluted nitrous acid it tinges the skin with a rose colour, and when evaporated leaves a rose-coloured deliquescent residuum.

(*c.*) It dissolves readily in caustic vegetable alkali, and may be precipitated from it by any acid, and also by mild volatile alkali; first as a jelly, and then breaking down into a white powder.

(2.) In distillation of the chalk-stone the lithic acid is decomposed, and yields the usual products of animal substances, *viz.* a fetid alkaline liquor, volatile alkali, and a heavy fetid oil, leaving a spongy coal; which when burnt in open air fuses into a white salt, that does not deliquesce, but dissolves

entirely in water, is alkaline, and when saturated with nitrous acid gives rhomboidal crystals.

These characteristic properties prove it to be mineral alkali.

(3.) Caustic vegetable alkali poured upon the chalk-stone, and warmed, dissolves the whole without emitting any smell of volatile alkali. From which it appears, that the volatile alkali obtained by distillation is a product arising from a new arrangement of elements, not so combined in the substance itself.

(4.) Water aided by a boiling heat dissolves a very small proportion of the gouty concretion, and retains it when cold. The lithic acid thus dissolved in combination with the alkali, is rather more than would be dissolved alone; so that by addition of marine acid it may be separated. While the solution continues warm no precipitate is formed; but as it cools, the lithic acid crystallizes on the sides of the vessel, in the same manner as the crystals called red sand do, when an acid is added to recent urine.

The gouty concrete may be easily formed by uniting the ingredients of which I have found it to consist.

(5.) If a fragment of lithic acid be triturated with some mineral alkali and a little warm water, they unite, and after the superfluous alkali has been washed out, the remainder has every chemical property of gouty matter.

The acid will not sublime from it, but is decomposed (2.) by heat: the alkali may be extracted by the vitriolic or marine (1.) or indeed by most acids. The compound requires a large quantity of water for its solution (4.), and while warm the solution yields no precipitate by the addition of an acid; but upon its

cooling the lithic crystals form, as in the preceding experiment.

In each case the crystals are too small for accurate examination, but I have observed, that by mixing a few drops of caustic vegetable alkali to the solution previous to the decomposition, they may be rendered somewhat larger. At the first precipitation, the crystals from gouty matter were not similar to those of lithic acid; but by redissolving the precipitate in water with the addition of a little caustic vegetable alkali, and decomposing the solution as before, while hot, the crystals obtained were perfectly similar to those of lithic acid procured by the same means.

Such then are the essential ingredients of the gouty concretion. But there might probably be discovered, by an examination of larger masses than I possess, some portion of common animal fibre or fluids intermixed; but whatever particles of heterogeneous matter may be detected, they are in far too small proportion to invalidate the general result, that 'gouty matter 'is lithiated soda.'

The knowledge of this compound may lead to a further trial of the alkalies which have been observed by Dr. CULLEN to be apparently efficacious in preventing the returns of this disease (First Lines, DLVIII.); and may induce us, when correcting the acidity to which gouty persons are frequently subject, to employ the fixed alkalies, which are either of them capable of dissolving gouty matter, in preference to the earths (termed absorbent) which can have no such beneficial effect.

Fusible Calculus.

My next subject of inquiry has been a species of calculus, that was first ascertained to differ from that of SCHEELE by Mr. TENNANT; who found that when urged by the heat of a blow-pipe, instead of being nearly consumed, it left a large proportion fused into an opaque white glass, which he conjectured to be phosphorated lime united with other phosphoric salts of the urine, but never attempted a more minute analysis.

Stones of this kind are always whiter than those described by SCHEELE, and some specimens are perfectly white. The greater part of them have an appearance of sparkling crystals, which are most discernible where two crusts of a laminated stone have been separated from each other.

I lately had an opportunity of procuring these crystals alone, voided in the form of a white sand, and thence of determining the nature of the compound stone, in which these are cemented by other ingredients.

The crystals consist of phosphoric acid, magnesia, and volatile alkali: the stone contains also phosphorated lime, and generally some lithic acid.

The form of the crystals is a short trilateral prism, having one angle a right angle, and the other two equal, terminated by a pyramid of three or six sides.

(6.) By heat the volatile alkali may be driven off from the crystals, and they are rendered opaque (or may be partially fused). The phosphorated magnesia may then be dissolved in nitrous acid; and by addition of quicksilver dissolved in the same acid, a precipitate of phosporated quicksilver is obtained,

from which the quicksilver may be expelled by heat, and the acid procured separate. By addition of vitriolic acid to the remaining solution, Epsom salt is formed, and may be crystallized, after the requisite evaporation of the nitrous acid, and separation of any redundant quicksilver.

(7.) These crystals require a very large quantity of water for their solution, but are readily soluble in most if not all acids; *viz.* vitriolic, nitrous, marine, phosphoric, saccharine, and acetous; and when precipitated from them re-assume the crystalline form.

(8.) From the solution in marine acid, sal ammoniac may be obtained by sublimation.

(9.) Although the analysis is satisfactory, the synthetic proof is (if possible) still more so. After dissolving magnesia in phosphoric acid, the addition of volatile alkali immediately forms the crystalline precipitate, having the same figure and properties as the original crystals.

(10.) If volatile alkali be cautiously mixed with recent urine, the same compound will be formed; the first appearance that takes place when a sufficient quantity of alkali has been gradually added, is a precipitate of these triple crystals.

These constitute the greater part of the fusible stone; so that a previous acquaintance with their properties is necessary, in order to comprehend justly the nature of the compound stone in which they are contained.

The most direct analysis of the compound stone is effected by the successive action of distilled vinegar, marine acid, and caustic vegetable alkali.

(11.) Distilled vinegar acts but slowly upon the calculus when entire; but when powdered, it immediately dissolves the

triple crystals, which may be again precipitated from it as crystals by volatile alkali; and if the solution has not been aided by heat, scarcely any of the phosphorated lime will be found blended with them.

In one trial the triple crystals exceeded $\frac{6}{10}$ of the quantity employed; but it seemed unnecessary to determine the exact proportion which they bear to the other ingredients in any one instance, as that proportion must vary in different specimens of such an assemblage of substances not chemically combined.

Marine acid, poured on the remainder, dissolves the phosphorated lime, leaving a very small residuum.

This is soluble in caustic vegetable alkali entirely, and has every other property of mere lithic acid.

The presence of volatile alkali in the compound stone may be shewn in various ways.

(12.) In the distillation of this stone there arises, first volatile alkali in great abundance, a little fetid oil, and lithic acid. There remains a large proportion charred. Water poured upon the remaining coal dissolves an extremely small quantity of a salt, apparently common salt, but too minute for accurate examination. Distilled vinegar dissolves no part of it even when powdered. Marine acid dissolves the phosphorated lime and phosphorated magnesia, leaving nothing but a little charcoal. From this solution vitriolic acid occasions a precipitate of selenite, after which triple crystals may be formed by addition of volatile alkali.

(13.) Marine acid also acts readily upon a fragment of the stone, leaving only yellowish laminæ of lithic acid. When the solution has been evaporated to dryness, sal ammoniac may be sublimed from it; and the two phosphorated earths are found

combined with more or less of marine acid, according to the degree of heat applied. If the proportion of the earth is wished to be ascertained, acid of sugar will separate them most effectually, by dissolving the phosphorated magnesia, and forming an insoluble compound with the lime.

(14.) Caustic vegetable alkali has but little effect upon the entire stone; but if heated upon the stone in powder, a strong effervescence takes place from the escape of alkaline air, and the menstruum is found to contain lithic acid precipitable by any other acid. Some phosphoric acid also, from a partial decomposition of the triple crystals, is detected by nitrated quicksilver.

(15.) The triple crystals alone are scarcely fusible under the blow-pipe; phosphorated lime proves still more refractory; but mixtures of the two are extremely fusible, which explains the fusibility of the calculus.

The appearance of the lithic strata, and the small proportion they bear to the other ingredients, shews that they are not an essential part, but an accidental deposit, that would be formed on any extraneous substance in the bladder, and which probably in this instance concretes during any temporary interval that may occur in the formation of the crystals.

I come now to what has been called

Mulberry Calculus.

This stone, though by no means overlooked, and though pointed out as differing from other species, has not, to my knowledge, been subjected to any farther analysis than is given, in the Second Volume of the Medical Transactions, by Dr. Dawson, who found that his lixivium had little or no effect

upon it; and in the Phil. Trans. by Mr. LANE, who, among other simple and compound stones, gives an account of the comparative effects of lixivium and heat upon a few specimens of mulberry calculus (*viz.* No. 7, 8, 9, 10.); but neither of these writers attempted to ascertain the constituent parts.

Though the name has been confined to such stones as, from their irregularly knotted surface and dark colour, bear a distant resemblance to that fruit, I find the species, chemically considered, to be more extensive, comprehending also some of the smoothest stones we meet with; of which one in my possession is of a much lighter colour, so as to resemble in hue, as well as smoothness, the surface of a hemp-seed. From this circumstance it seems not improbable, that the darkness of irregular stones may have arisen from blood voided in consequence of their roughness.

The smooth calculus I find to consist of lime united with the acids of sugar and of phosphorus. The rougher specimens have generally some lithic acid in their interstices.

(16.) Caustic vegetable alkali acquires a slight tinge from a fragment of this kind of stone, but will not dissolve it. When powdered it is thereby purified from any quantity of lithic acid that it may contain. Phosphoric acid will then dissolve out the phosphorated lime, and the remainder, after being washed, may be decomposed by the vitriolic. The affinity of this acid for a certain proportion of lime is superior even to that of acid of sugar; selenite is formed, and the acid of sugar may be crystallized, and by the form of its crystals recognized, as well as by every other property. It is easily soluble, occasions a precipitate from lime water, and from a solution of selenite,

and with mineral alkali forms a salt that requires a large quantity of water for its solution.

(17.) When the stone has been finely powdered, marine acid will slowly dissolve all but any small quantity of lithic matter which it may contain. After the solution has been evaporated to dryness no part is then soluble in water, the marine acid being wholly expelled. When the dried mass is distilled with a greater heat, the saccharine acid is decomposed, and a sublimate formed, still acid and still crystallizable, but much less soluble in water, and which does not precipitate lime from lime water. After distillation the remainder contains phosphorated lime, pure lime, and charcoal; and when calcined in the open air, the charcoal is consumed and the whole reduced to a white powder. The two former may be dissolved in marine acid, which when evaporated to dryness will be retained only by the lime; so that water will then separate the muriated lime, and the phosphorated may afterwards be submitted to the usual analysis.

Bone-earth Calculus.

Beside that of SCHEELE, and the two already noticed, there is also a fourth species of calculus, occasionally formed in the bladder, distinct in its appearance, and differing in its component parts from the rest; for it consists entirely of phosphorated lime.

Its surface is generally of a pale brown, and so smooth as to appear polished; when sawed through, it is found very regularly laminated; and the laminæ in general adhere so slightly to each other, as to separate with ease into concentric crusts. In a specimen with which I was favoured by Dr. BAILLIE, each

lamina is striated in a direction perpendicular to the surface, as from an assemblage of crystallized fibres.

This calculus dissolves entirely, though slowly, in marine or nitrous acid, and, consisting of the same elements as earth of bones, may undergo a similar analysis, which it cannot be necessary to particularize.

By the blow-pipe it is immediately discovered to differ from other urinary calculi: it is at first slightly charred, but soon becomes perfectly white, still retaining its form, till urged with the utmost heat from a common blow-pipe, when it may at length be completely fused. But even this degree of fusibility is superior to that of bones. The difference consists in an excess of calcareous earth contained in bones, which renders them less fusible. This redundant portion of lime in bones renders them also more readily soluble in marine acid, and may, by evaporation of such a solution, be separated, as in the last experiment upon mulberry calculus. The remaining phosphorated lime may be re-dissolved by a fresh addition of marine acid; and being now freed from redundant lime, will, upon evaporation of the marine acid, assume a crystalline form. As the laminated calculus contains no excess of lime, *that* will at once yield such crystals: their appearance will be described in the succeeding experiment.

Calculus from the Prostate Gland.

There is still another calculus of the urinary passages, though not of the bladder itself, which deserves notice, not from the frequency of its occurrence, but from having been supposed to give rise to stone in the bladder. I mean the small stones which are occasionally found in the prostate gland. Those

that I have seen, and which, by favour of Mr. ABERNETHY, I have had an opportunity of examining, were from the size of the smallest pin's head to that of pearl barley, in colour and transparency like amber, and appeared originally to have been spherical; but from contiguity with others, some had flattened surfaces, so as at first sight to appear crystallized.

These I find to be phosphorated lime in the state of neutralization, tinged with the secretion of the prostate gland.

(18.) A small fragment being put into a drop of marine acid, on a piece of glass over a candle, was soon dissolved; and upon evaporation of the acid, crystallized in needles, making angles of about 60° and 120° with each other.

Water dropped on the crystals would dissolve no part of them; but in marine acid they would re-dissolve, and might be re-crystallized.

(19.) Vitriolic acid forms selenite with the calcareous earth.

(20.) By acid of nitrated quicksilver, phosphoric acid is readily obtained.

(21.) When heated this calculus decrepitates strongly; it next emits the usual smell of burnt animal substances, and is charred, but will not become white though partially fused. It still is soluble in marine acid, and will in that state crystallize more perfectly than before. Hence I conclude, that these stones are tinged with the liquor of the prostate gland, which in their original state (18.) somewhat impedes the crystallization.

This crystallization from marine acid is so delicate a test of the neutral phosphorated lime, that I have been enabled by that means to detect the formation of it, although the quantities were very minute. The particles of sand which are so

generally to be felt in the pineal gland, have this for their basis; for I find that after calcination they crystallize perfectly from marine acid.

I have likewise met with the same compound in a very pure state, and soft, contained in a cyst under the pleura costalis.

On the contrary, ossifications (properly so called) of arteries and of the valves of the heart, are similar to earth of bones, in containing the redundant calcareous earth; and I believe also those of veins, of the bronchiæ, and of the tendinous portion of the diaphragm, have the same excess; but my experiments on these were made too long since for me to speak with certainty.

To these I may also add the incrustation frequently formed upon the teeth, which, in the only two specimens that I have examined, proved to be a similar compound, with a very small excess of lime.

Though I do not at present presume to draw conclusions with regard to the treatment of all the diseases in question, some inferences cannot pass unobserved.

The sand from the pineal gland, from its frequency hardly to be called a disease, or when amounting to disease most certainly not known by its symptoms, would, at the same time, if known, be wholly out of the reach of any remedy.

The calculi of the prostate are too rare, perhaps, to have been ever yet suspected in the living body, and are but indirectly worthy of notice. For if by chance one of them should be voided with the urine, a knowledge of its source would guard us against an error we might otherwise fall into, of proposing the usual solvents for urinary calculi.

The bone-earth calculus, although so nearly allied to the

last, is still manifestly different, and cannot be supposed to originate from that source; but if ever the drinking of water impregnated with calcareous earth gave rise to a stone in the bladder, this would most probably be the kind generated, and the remedy must evidently be of an acid nature.

With respect to the mulberry calculus, I fear that an intimate knowledge of its properties will leave but small prospect of relief from any solvent; but by tracing the source of the disease we may entertain some hopes of preventing it. As the saccharine acid is known to be a natural product of a species of oxalis, it seems more probable that it is contained in some other vegetables or their fruits taken as aliment, than produced by the digestive powers, or secreted by any diseased action of the kidneys. The nutriment would therefore become a subject of minute inquiry, rather than any supposed defect of assimilation or secretion.

When a calculus is discovered, by the evacuations, to be of the fusible kind, we seem to be allowed a more favourable prospect in our attempts to relieve: for here any acid that is carried to the bladder will act upon the triple crystals, and most acids will also dissolve the phosphorated lime; while alkalies, on the contrary, would rather have a tendency to add to the disease.

Although, from want of sufficient attention to the varieties of sediment from urine, and want of information with regard to the diversity of urinary calculi, the deposits peculiar to each concretion are yet unknown; it seems probable that no long course of observation would be necessary to ascertain with what species any individual may be afflicted.

The lithic, which is by far the most prevalent, fortunately

affords us great variety of proofs of its presence. Particles of red sand (as they are called) are its crystals. Fragments also of larger masses, and small stones, are frequently passed; and it is probable that the majority of appearances in the urine called purulent, are either the acid itself precipitated too quickly to crystallize, or a neutral compound of that acid with one of the fixed alkalies.

Beside this species, the fusible calculus has afforded decisive marks of its presence in the case which furnished me with my specimen of triple crystals; and by the description given by Mr. FORBES (in his Treatise upon Gravel and Gout, ed. 1793, p. 65.) of a white crystallized precipitate, I entertain no doubt that his patient laboured under that variety of the disease.